ATTACHMENT A
GROUNDWATER RISK SCREENING EVALUATION

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The potential risks associated with groundwater at the Site are expected to be minimal because the future uses are limited and because the RI results indicate that low concentrations of DNT represent the only Site-related constituents present in the groundwater.

Irrigation of the golf course after the Site is developed represents the only potential future use of groundwater at the Site. No other future uses are planned because the City of Dupont will provide water for all residential and industrial uses. Golfers or occasional visitors are not expected to come in contact with the irrigation water on any significant basis. Thus, risks were quantified for exposure by a golf course worker responsible for operating the irrigation system. Risks were evaluated assuming dermal contact with irrigation water as well as drinking of the irrigation water. Because of the greater potential frequency and duration of contact with irrigation water, a golf course worker represents the most conservative exposure scenario. Highly conservative assumptions were used throughout this screening evaluation to provide a high level of confidence that use of Site groundwater for golf course irrigation will be protective of human health.

The potential cancer risks associated with exposure to groundwater are below 1×10^{-6}, even with the highly conservative assumptions used in this screening evaluation. Therefore, groundwater does not represent a media of concern for impact to human health. The potential risks were quantified as presented below:

Dermal Contact with Groundwater

The dermally absorbed dose is calculated with the following equation:

$$DAD = \left(\frac{DA_{event} \times EV \times ED \times EF \times A}{BW \times AT} \right)$$

Where:

DAD =	dermally absorbed dose in mg/kg-day
DA_{event} =	absorbed dose per event in mg/cm^2-event
EV =	event frequency in events/day
ED =	exposure duration in years
EF =	exposure frequency in days/year
A =	skin surface area available for contact in cm^2

BW = body weight in kg
AT = averaging time in days

The following values were substituted into the above equation:

DA_{event} = 5.9×10^{-9} mg/cm^2-event; as calculated separately below
EV = 1 event/day; which assumes that a groundskeeper sets up and attends to watering systems once per day
ED = 9 years
EF = 180 days/year; a Site-specific value suitable for the Pacific Northwest climate
A = 2,000 cm^2; equal to the average surface area of an adult's hands and forearms
BW = 70 kg; MTCA and EPA default value
AT= 25,550 days; the averaging time for carcinogens (70 years) times 365 days/year

DA_{event} is calculated with the following equation:

$$DA_{event} = 2K_p C_v \sqrt{\frac{6\,\tau\, t_{event}}{\pi}}$$

Where:
K_p= chemical-specific permeability constant in cm/hour
C_v= chemical concentration in water in mg/cm^3
τ = lag time in hours; this term is used to account for chemicals entering the skin at a rapid rate during initial contact (a non-steady state phenomenon)
t_{event}= the duration of the exposure event in hours
π = pi; a constant equal to 3.14

Values of 3.8×10^{-3} cm/hour and 1.1 hour for K_p and τ, respectively, were taken from EPA (1992). The value of K_p for 2,4-DNT was used as the higher value for the two given DNT isomers. t_{event} was assumed to be equal to 0.5 hour, which is a conservative approximation of the amount of time a golf course worker might be in contact with irrigation water per exposure event. C_v was assumed to be 0.76 μg/L, the highest DNT concentration ever detected in Site aquifers (converted to 7.6×10^{-7} mg/cm^3) as an additional measure of conservatism.

Calculating DA_{event} with the above values results in $DA_{event} = 5.9 \times 10^{-9}$. Substituting this into the equation used to calculate DAD results in DAD = 1×10^{-8}. Multiplying DAD by the oral CSF of 0.68 gives an estimated

risk by this pathway of 7×10^{-9}, or 7 in 1 billion. Therefore, potential incremental risks associated with this pathway are well below thresholds of risk management consideration, even with the highly conservative assumptions that a worker would have their arms immersed in water containing maximum Site DNT concentrations for a period of one-half hour every day for 180 days per year.

For EF, the upper-bound default for worker exposure is normally 250 days/year. However, the climate in the Pacific Northwest is such that golf course irrigation is not expected to exceed 6 months per year. Assuming the golf course is operating 7 days per week for 6 months, an EF of 180 days/year was assumed. This further assumes that the golf course will be watered on every one of those 180 days, which is a conservative assumption.

The event time and frequency of 0.5 hour/event, 1.0 event/day, respectively, may not capture the actual conditions by which a worker is exposed. Assuming that a worker makes contact with the irrigation equipment or with materials that have come into contact with the irrigated sections of the golf course, exposure may, in fact, occur with greater frequency for much shorter periods of time. To examine this, the above calculations were repeated with $\tau_{event} = 0.1$ hour (six minutes), and EV = 16 events/day. That is, an individual makes contact with irrigation water for 6 minutes out of every 15 minutes for four hours each working day, which are highly conservative assumptions. With these values substituted in the above equations, $DA_{event} = 2.6 \times 10^{-9}$, DAD = 7.7×10^{-8}, and the risk is determined to be 5×10^{-8}, or 5 in 100 million. Therefore, exposures of greater frequency and shorter time still results in estimated potential incremental risks well below risk management thresholds.

Ingestion of Groundwater

The orally absorbed dose is calculated with the following equation:

$$Intake = (mg/kg\text{-}day) = \left(\frac{CW \times IR \times EF \times ED}{BW \times AT}\right)$$

Where:

CW =	chemical concentration in water in mg/L
IR =	ingestion rate in liters/day
EF =	exposure frequency in days/year
ED =	exposure duration in years
BW =	body weight in kg

AT = averaging time (period over which exposure is averaged - days)

The following values were substituted into the above equation:

CW = 0.76 μg/L, the highest detected DNT concentration in groundwater at the Site
IR = 1 liter/day. This equals half of the EPA default IR of 2 liters/day
EF = 180 days/year; a site-specific value suitable for the Pacific Northwest climate
ED = 9 years
BW = 70 Kg; MTCA and EPA default value
AT = 25,550 days; the averaging time for carcinogens (70 years) times 365 days/year

The value of 1 liter per day for the IR is based on the assumption that a golf course worker consumes half their daily intake of 2 liters/day from irrigation water while at work. This represents a highly conservative assumption since it assumes a worker would preferentially drink water from the golf course irrigation system rather than the water specifically provided for drinking water at the golf course (from the City of Dupont water supply). Because water used for irrigation may not be suited for drinking water purposes, the assumption of any drinking water exposure to irrigation water, much less half of their intake, is highly conservative. Values for CW, EF, ED, BW, and AT are the same as used above for dermal exposure.

Potential risk was calculated for both carcinogenic and non-carcinogenic end points for exposure to DNT in drinking water using EPA guidance (1989). A cancer slope factor of 0.68 and an oral reference dose of 0.001 mg/kg-day were used. The cancer risk was calculated as 5×10^{-7}, considerably below 1 in 1 million (10^{-6}). The non-cancer risk was calculated as 7×10^{-4}, much less than a hazard quotient of 1.0. These calculated risks are well below risk management thresholds.

References for Attachment A

EPA, 1989. Risk Assessment Guidance For Superfund. Human Health Evaluation Manual Part A. EPA 1985.701A, July 1989.

EPA, 1992. Dermal Exposure Assessment: Principles and Applications. Interim Report. Office of Research and Development, Washington, DC. EPA/600/8-91/011B. January 1992.